



CELLULAR AGRICULTURE

A GENERAL INTRODUCTION

 **proveg**
CELL-AG PROJECT

Picture by Mosa Meat

What is cellular agriculture

Cellular agriculture is the production of animal-based products from cell cultures, rather than directly from animals. The aim is to provide people with the animal-based products that they know and like, but with numerous human health benefits, a lighter impact on the environment, and a reduction in animal use and slaughter. Cellular agriculture currently comprises two different approaches: cell cultivation (cellular) and precision fermentation (acellular).

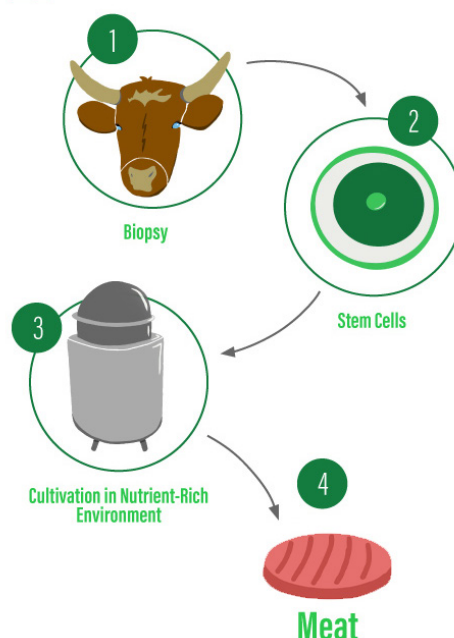
The cell-cultivation method

The cell-cultivation method refers to growing meat directly from cells. Cells are the building blocks of life. By cultivating cells to produce meat, fish, and seafood, the raising and slaughtering of animals can be avoided.

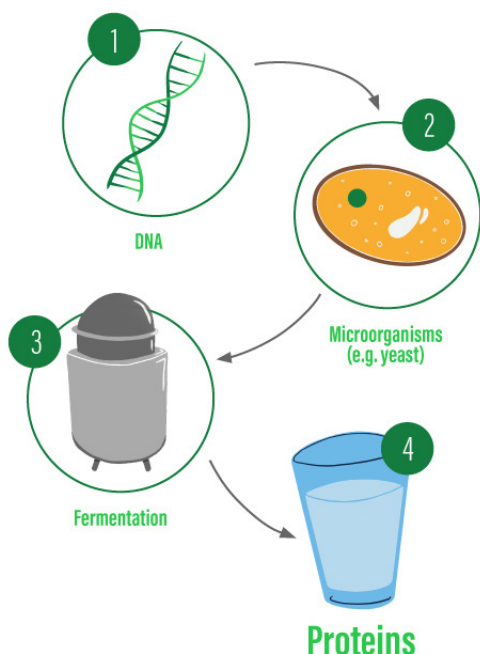
To produce meat and seafood, stem cells are first sampled from animals through a biopsy. These cells are then fed with nutrients in large vats, also known as cultivators, where they multiply and differentiate. As they grow, they become muscle tissue, which is the main component of meat.

A number of startups and companies are developing a variety of cultured foods, including beef, pork, chicken, fish, and seafood.

CELL CULTIVATION: CULTURED MEAT PRODUCTION



FERMENTATION: CULTURED MILK PRODUCTION



The precision-fermentation method

The precision-fermentation method refers to the use of microorganisms rather than cell cultures to produce milk or egg-white proteins, for example.

These products can be grown directly from microorganisms such as yeast, in a similar fermentation process to that which has been used for many years in the food industry to produce enzymes such as rennet (a key ingredient for producing cheese) or vanillin (the main component of vanilla flavor), as well as other products. Startups and companies are currently developing milk, ice cream, cheese, gelatin, and egg white.

Some products have already entered the market, including Perfect Indulgence, an ice cream based on Perfect Day's flora based dairy proteins.



Picture by Free To Use Sounds

Blending plant-based and cultured ingredients

The potential of hybrid products

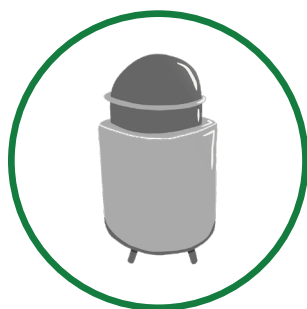
Hybrid products combine plant-based and cultured ingredients to develop tasty and sustainable products that will also potentially be cost-effective. This new product category shows much promise in terms of texture and taste, while adding an appealing juiciness. For instance, adding cultured fat to a plant-based chicken nugget could provide the genuine taste of chicken as well as improving juiciness and meatiness, while providing an authentic texture, thanks to the plant-based proteins. The first proof-of-concept of hybrid products, chicken nuggets comprising 80% vegetable protein and 20% cultured fat, was unveiled in March 2019 by Peace of Meat, during a public event organised in Berlin.¹

Looking at it this way, plant-based and cultured products are not mutually exclusive categories but actually form a highly promising complementary strategy – together, they have the potential to accelerate market entry by combining two different approaches in order to arrive at a perfect result, rather than perfecting just one approach completely.

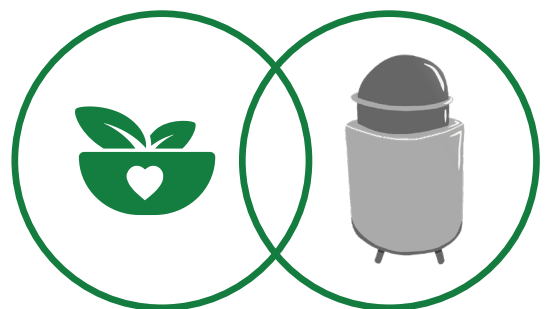
The solutions landscape



Plant-based



Cultured and
fermentation-derived



Hybrid

THE BENEFITS OF CELLULAR AGRICULTURE



PRO HEALTH

Cultured products have the potential to be **safer and healthier** than conventional animal-based products. With no animal husbandry involved, there would be a **vastly reduced risk of contamination from pathogens** such as Listeria, E. Coli, or Salmonella, as well as a **decrease in zoonotic diseases** such as mad cow disease, swine flu, avian flu, and COVID-19. As culturing environments are completely sterile, there is **no need for antibiotics**. In addition, growing cultured animal-based products offers the potential for **improving their nutritional composition**. In meat, for example, saturated fatty acids could be replaced with omega fatty acids, creating a cholesterol-free product.



PRO ANIMALS

Contemporary factory farming causes great suffering to more than 75 billion land animals,² around 37-120 billion farmed fish, and 800 million-2.3 trillion wild fish.³ Cellular agriculture could result in a dramatic **reduction in animal use and slaughter**, and presents a **major step towards improving animal welfare**. Since there would be no need to kill animals for meat and no need for animals at all in order to produce eggs and dairy, cellular agriculture could spare tens of billions of animals a life of suffering, every year. Cellular agriculture could also **contribute to wildlife preservation**. Cultivating wild animal meat, ivory, and other coveted products from endangered species could help to reduce poaching and hunting.



PRO ENVIRONMENT

While it's too early to know the precise environmental footprint of cellular agriculture, the latest life-cycle assessment showed that cultured meat could result in a **reduction of 92% of carbon footprint**, if renewable energy is used in the production process, **95% of land use** and **78% of water requirements**, compared to conventional meat production.⁴ Freed-up land could serve to produce renewable energy or be used for CO2 sequestration, reforestation, or biodiversity protection. Local cultured-production facilities could also lead to a reduction in ground transportation and shipping pollution.



PRO JUSTICE

Cellular agriculture could help **reduce the harsh competition between animal feed and staple human foods in developing countries**, which currently impacts negatively on the resources required for people to grow their own basic plant-based staple foods. Cellular agriculture could **help to free up resources** that are currently used for animal agriculture, including 75% of global maize production,⁵ a third of grains, and two thirds of soya,⁶ as well as 20% of freshwater.⁷ The resultant increases in localised food production could increase food security and **promote vibrant local economies**, especially in times of crisis when supply chains are disrupted. Ultimately, some startups are confident that people will be able to make their own meat at home, similarly to brewing beers.⁸ To that end, Shojinmeat Project, a citizen-science project, aims to make cultivating meat accessible to everyone.⁹



PRO TASTE

Products of cellular agriculture have the potential to **match people's preferences and habits** without the need for behaviour change. People can continue eating the animal-based products they know and like, without all the negative effects. In addition, they can be respectful of family traditions and of people with special physiological or nutritional needs

FOCUSING ON THE OPPORTUNITIES WHILE BEING AWARE OF THE CHALLENGES

Agro food sector — becoming part of the solution

Conventional agrifood companies are increasingly exploring the possibilities of cellular agriculture in order to make our food system more sustainable and no longer dependent solely on animal farming to satisfy our demand for animal protein. A growing number of universities, along with about 60 companies and startups around the world, including some of the world's leading meat producers, are currently working on developing cellular-agriculture products. According to the consulting firm Kearney¹⁰, cultured meat could represent 35% of global meat consumption by 2040.

Corporate venture capital investments in cultured meat companies between 2016-2020¹¹



USA: Tyson, one of the world's largest processors and marketers of chicken, beef, and pork, invested in the cultured-meat company Future Meat Technologies in 2018 and Memphis Meats in 2017, 2018, and 2020.

USA: Cargill, the largest privately held corporation in the United States in terms of revenue, invested in the cultured-meat company Memphis Meats in 2017 and Aleph Farms in 2019.

USA: Griffith Foods, a product-development company specialising in food ingredients, invested in the cultured-fish company BlueNalu in 2020.

USA: Pulmuone Foods, a leader in providing fresh, natural, and organic food products, invested in the cultured-fish company BlueNalu in 2020.

USA: Rich Products Ventures, a venture-capital arm of the multinational food corporation Rich Products Corporation, invested in the cultured-fish company BlueNalu in 2020.

USA: Sumitomo Corporation of Americas, one of the largest general trading companies worldwide, invested in the cultured-fish company BlueNalu in 2020.

Netherlands: Nutreco, a Dutch producer of animal-nutrition products, fish feed, and processed-meat products, invested in the cultured-fish company BlueNalu in 2020 and the cultured-meat company Mosa Meat in 2020.

Netherlands: The venture-capital arm of Merck, a global science and technology company, invested in the cultured-meat company Mosa Meat in 2018.

Switzerland: M-Industry, a company belonging to Migros, the first retailer in Switzerland, invested in the cultured-meat company Aleph Farms in 2019.

Switzerland: Bell Food Group, one of Europe's leading meat producers and suppliers of ready-to-eat products, invested in the cultured-meat company Mosa Meat in 2018 and 2020.

Austria: Inter Alloys, one of the leading suppliers of precision tubes, invested in the cultured-meat supplier Biotech Foods in 2017.

Germany: PHW-Gruppe Corporation, the largest German poultry breeder and processor and one of the largest companies in the German food industry, invested in the cultured-meat company SuperMeat in 2018.

Israel: Neto Malinda Trading, an Israel-based company involved in the food-processing sector, invested in the cultured-meat company Future Meat Technologies in 2018.

Israel: Ophectra Real Estate & Investments, a biotechnology, bio-printing, and agritech company, invested in the cultured-meat company MeaTech in 2019.

Israel: Strauss Group, one of the largest food-product manufacturers in Israel, invested in the cultured-meat company Aleph Farms in 2019.

Japan: Euglena, a Japan-based company engaging in the healthcare, energy, and environmental sectors, invested in the cultured-meat company IntegriCulture in 2018.

Japan: MTG, a Japanese brand-development company, invested in the cultured-meat company IntegriCulture in 2018.

Governments – helping to build the scientific foundation for a healthy, sustainable, and just food system

Promising regulatory initiatives for creating guidelines for cellular agriculture are currently in progress in some parts of the world. Food-regulatory authorities are already familiar with the use of cellular bioengineering in food. For example, rennet, an enzyme found in the stomachs of ruminant mammals which is used to produce many kinds of cheese, is already produced directly through cellular agriculture. In addition, the positive environmental impact, food-safety aspects, and economic prospects of cultured animal-based products are likely to drive governments to support cellular agriculture.

COVID-19 has demonstrated the devastating effects of our current food system, as the use of wild animals and farmed animals for food significantly contributes to zoonotic spillover and the spread of dangerous diseases. The effects of the COVID-19 crisis go way beyond individual and public health to include massive social, political, and economic impacts. Given the predicted sharp increase in meat demand and production over the coming decades, **cellular agriculture could help the global food system to become part of the solution as a risk-mitigation strategy against future zoonotic pandemics.**

Recent examples of administrative bodies supporting cellular agriculture



In North America

In November 2018, the American Food and Drug Administration (FDA) proposed a regulatory framework favourable to the marketing of cultured foods.¹² In March 2020, the FDA recognised the fermented whey protein produced by the startup Perfect Day as safe, accrediting it with the ‘generally recognized as safe’ (GRAS) designation.¹³

In Europe

BioTech Foods, a Spanish cultured-meat company, is currently leading a €5.2 million project funded by the Spanish government to investigate the health benefits of cultured meat.¹⁴ Biotech has also been awarded a €2.7 million grant under the EU’s Horizon 2020 R&D funding framework for its cultured research programme Meat4all.¹⁵ In August 2020, the Icelandic plant-based biotech company ORF Genetics was awarded a €2.5 million grant from the Grant Management Services of the European Commission to develop plant-based growth mediums.¹⁶ In December 2019, the Dutch cultured-meat company Meatable also received a \$3 million grant from the European Commission, through the Eurostar Programme.¹⁷ In 2019, the Flemish government awarded a 3,6 million euro grant to a Belgian consortium to grow fat and liver cells in order to make foie gras.¹⁸ In January 2020, the Dutch Parliament discussed the potential of cellular agriculture in a plenary debate, with the majority of the representatives voting in favour of two motions aimed at stimulating the development of cultured meat.¹⁹



In Asia

In December 2020, Singapore became the first country in the world to approve sales of cultured meat.²⁰ In Jun 2020, a member of China’s CPPCC in (The National Committee of the Chinese People Political Consultative Conference) spoke out in a high-level plenary meeting with the National People’s Congress with the intent of advancing cellular agriculture, presenting it as a keys means of making China’s food supply more sustainable and crisis-resilient.²¹ In July 2020, Japan’s Agriculture, Forestry, and Fisheries Ministry announced the creation of new rules and regulations for meat-alternative products, including cellular agriculture.²²



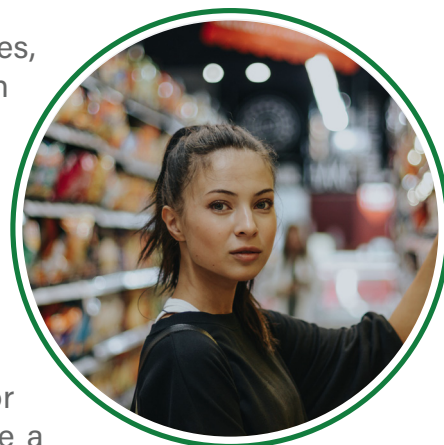
Consumers — supporting cellular agriculture as they become more informed

Several surveys conducted in Europe and in the US show that **the more informed people are about the various benefits of cellular agriculture, the more open they are to the concept of cultured meat**. According to studies, 50%²³ to 95%²⁴ of European consumers are willing to purchase cultured meat, after having been provided with relevant information. Another study showed Chinese respondents were very likely or extremely likely to purchase cultured meat, twice as likely as American respondents in the same study (59.3% versus 29.8%) and 10% more likely than participants from India.²⁵ Most studies also suggest that the acceptance of cultured meat is higher among men, the educated, the young, urbanites, and meat consumers.²⁶

Challenges to overcome

Although cellular agriculture shows very promising possibilities, many challenges still need to be addressed before products can be taken to market. The most pressing challenges currently facing cellular agriculture include research, regulatory aspects, and consumer acceptance.

- **More publicly-funded, open-source research** is required to address technical challenges such as growth mediums, cell lines, and consumer safety.
- **Further development of the regulatory framework** for cellular-agriculture products is needed in order to create a supportive environment for producers and consumers.
- **More widespread information** is required in order to pave the way for the fair and objective reception of cultured products in society.



ADDITIONAL RESOURCES

[ProVeg CellAg Project](#)

[Glossary](#)

[FAQ](#)

[High resolution pictures](#)

[Quotes](#)

[Promising startups in the field](#)

[Contacts](#)

- **Cultivated, cultured, cell-based:** all these terms refer to products from cellular agriculture. Studies have shown that these terms are preferable to other terms such as 'in-vitro', 'lab-grown', 'artificial', and 'synthetic.'
- **Cell:** the building block of all life. It is the smallest biological unit of a plant or animal.
- **Cell culture medium:** a solid, liquid, or semi-solid medium that is designed to support the growth of microorganisms or cells. The culture medium is composed of carbohydrates, amino acids, fats, vitamins, minerals, and growth factors, all essentials for cell culture to grow inside an animal or bioreactor
- **Cell division:** the process by which a parent cell divides into two or more daughter cells.
- **Cell line:** a cell culture developed from a single cell and therefore consisting of cells with a uniform genetic make-up.
- **Immortalised cell lines:** cells that are able to keep dividing for a longer period of time.
- **Bioreactor/cultivator:** a device or system that supports a biologically active environment. Bioreactors are similar to the vats that are used in breweries to brew beer, and provide a clean and controlled environment for cells to grow.
- **Scaffolding:** scaffolds are solid materials that provide a structure inside a bioreactor for the cells to grow into the desired meat product.
- **Stem cell:** a cell that can develop into any other type of cell, either through self-replication or differentiation.
- **Protein:** large molecules composed of one or more chains of amino acids joined by peptide bonds. They include many essential biological compounds such as enzymes, hormones, and antibodies.
- **Amino acids:** group of organic molecules that constitute the building blocks of proteins.



ProVeg International

ProVeg is an international food awareness organisation working to transform the global food system by replacing conventional animal-based products with plant-based and cultured alternatives.

ProVeg works with international decision-making bodies, governments, food producers, investors, the media, and the general public to help the world transition to a society and economy that are less dependent on animal agriculture and more sustainable for humans, animals, and our planet.

ProVeg has permanent-observer status with the UNFCCC, is accredited for UNEA, and has received the United Nations' Momentum for Change award.

ProVeg Incubator

The ProVeg Incubator is the world's leading Incubator of plant-based and cultured food startups. The ProVeg Incubator is shaping the future of food by exclusively supporting pioneering companies that are developing disruptive alternatives to animal-based products and services. Since its launch in November 2018, the ProVeg Incubator has worked with 40 startups from all over the world, including Europe, India, Latin America, Israel, and Indonesia. To date, our alumni have collectively raised more than €18 million and launched over 40 products.

ProVeg's position on cellular agriculture and why it matters for a plant-based organisation

ProVeg considers plant-based eating to be the perfect multiproblem solution to many of the world's problems. However, when it comes to taste and accessibility, plant-based alternatives do not appeal to all consumers. This is why ProVeg also acknowledges the huge potential of cellular agriculture and cultured meat, eggs, dairy, and seafood products as a complementary strategy towards achieving ProVeg's mission of reducing animal production by 50% by 2040 (50by40).

While cultured products are not yet commercially available, they appear poised to represent a substantial share of the protein sector in the coming years. According to the consulting firm Kearney, cultured meat could constitute 35% of global meat consumption by 2040. As a complement to the increasing number of plant-based products available on the market, cultured products could potentially play a major role in achieving 50by40.

The CellAg Project (CAP) started exploring the potential of creating animal-based products without animals, with an interdepartmental team in 2019. Working in close strategic coordination with other key players, CAP is currently focused on raising awareness and increasing the acceptance of cellular agriculture, building a cross-sectoral network, and incentivising collaboration within the sector in order to further this novel approach to food production.

Through the CellAg Project, the ProVeg [Incubator](#), the [New Food Invest and New Food Conference events](#), and the [Food Industry & Retail department](#), ProVeg International is working to further the development of cellular agriculture, and support stakeholders in their efforts to bring cultured alternatives to market. In doing so, we aim to help the world transition to a more sustainable, healthy, just, and humane food system.

Endnotes

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